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(54) **A method of rock bolting, and a device, and a roof bolting apparatus.**

(57) In roof bolting, when an anchor rod (24) is to be inserted in a borehole (26) in the rock, a cement grout is ejected as a jet from a nozzle (22) located at the mouth of the borehole to partially fill the hole before the rod is forced into the borehole. The jet of grout should have such a velocity that it reaches the bottom of the borehole. A grout pump (45, 60) forces the grout through a hose (28) to the nozzle (22).

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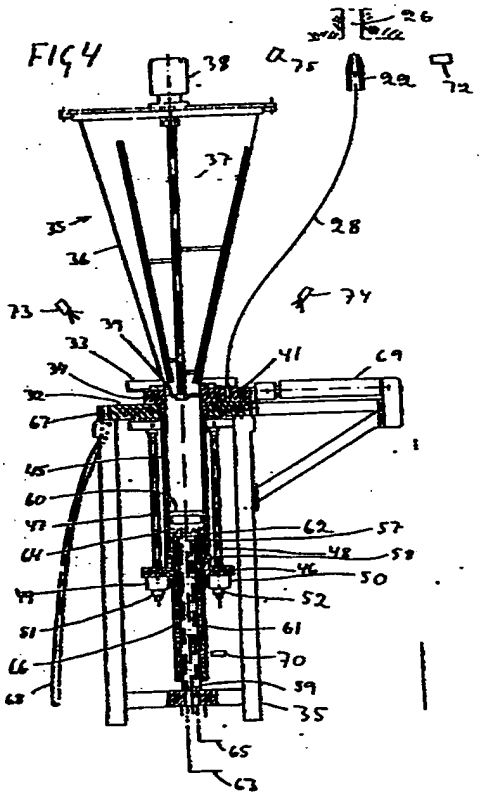
FIG 4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A Method of Rock Bolting, and a Device, and a Roof Bolting Apparatus

This invention relates to a method of rock bolting in which a hole is drilled in the rock, a batch of bulk grout is introduced into the borehole and an anchor rod is forced into the borehole. The invention relates also to a device for carrying out the introduction of grout in the borehole and a roof bolting apparatus.

In US-A-4158520, a roof bolting apparatus is shown which comprises a rock drill, a bolt setting machine, and a loading device for two-component resin cartridges. The resin cartridges are blown into the borehole and their contents are mixed by the bolt to a hardening mass. In GB-A-953056, cartridges for roof bolting are described which contain a dry cement mortar and a separate compartment of water. It is also known to insert a hose to the bottom of the borehole and to pass a bulk cement grout through the hose while slowly withdrawing the hose. This method can be used with the roof bolting apparatus disclosed in US-A-4351625.

The invention will be described with reference to the accompanying drawings.

Fig 1 is a side view of a mobile rock bolting rig according to the invention.
Fig 2 is a top elevational view of the rig shown in Fig 1.
Fig 3 is an enlarged fragmentary view seen as indicated by the arrows 3-3 in Fig 1.
Fig 4 is a side view of some details shown in Figs 1 and 2.
Fig 5 shows a rock bolt that can be set by means of the rig.

The rock bolting rig shown on the drawings comprises a wheeled chassis 12 on which a boom 13 is swingably mounted. The boom 13 carries pivotably a feed beam 14. A slide 15 is mounted on the feed beam 14 and it can be moved along the feed beam by means of a non-illustrated hydraulic feeding device in a conventional way.

A machine shifting device 16 is mounted on the rear end of the feed beam 14. When the slide 15 is in its rearmost position as shown in Fig 3, a rock drill 17 which is shown in its operational position on the slide 15 can be moved off the slide 15 to the left in the figure and a bolt setter 29 can replace it on the slide 15. This lateral shifting is effected by means of a hydraulic cylinder 18. The bolt setter may include a hydraulic motor so that it can rotate the bolt while forcing it into the borehole. At the front end of the feed beam 14, a support 19 is mounted to pivot about an axis that is parallel with the feed beam. The support 19 carries a guide 20 for a drill steel 21, a nozzle 22, and a guide 23 for a rock bolt 24 of the kind shown in Fig 7. A magazine for rock bolts is indicated in Figs 1 and 2 by reference numeral 43. The bolt 24 or anchoring rod comprises a re-bar 53, a washer or plate 54, and a nut 55. By means of a hydraulic cylinder 25, the drill steel guide 20, which is shown in its operational position, can be swung aside and the nozzle 22 and the guide 23 for the rock bolt can be alternatively swung into their operational positions in line with a borehole 26 drilled by the rock drill 17 and its drill steel 21. The very front of the feed beam 14 comprises a support pad 27 of hard rubber that is arranged to be forced to take support against the rock.

A hose 28 couples the nozzle 22 to a cement grout supplying device 30 that is mounted on the chassis 12.

The cement grout supplying device 30 comprises a frame 31 mounted on the chassis 12. The frame 31 includes a plate 32 and guides 33 for guiding a slide or shutter 34 on the plate 32. The shutter 34 carries a cement mixer 35 with a conical housing 36 and a rotatable agitator 37 that is driven by a hydraulic motor 38 on a cover 42 of the housing 36. The housing 36 forms a mixing chamber which is also a storage chamber.

The bottom end of the conical housing 36 is coaxial with a hole 39 in the shutter 34. The agitator 37 is journalled in a spider 40 mounted in the hole 39. The hose 28 is coupled to a hole 41 in the shutter 34.

A cylinder 45 is suspended in yoke 46 which is suspended in two bolts 47, 48. Two short hydraulic jacks 49, 50 are arranged as spacers between the yoke 46 and the nuts 51, 52 on the bolts 47, 48.

The jacks 49, 50 are coupled to constantly bias the end face of the cylinder 45 against the slide 34 with a force that permits movement of the slide. Then, the jacks 49,50 can be actuated to clamp the cylinder 45 against the shutter at a considerably larger force to provide for or seal that withstands high pressure. Instead of using the jacks 49, 50 for applying the constantly applied force on the cylinder 45, one can couple springs between the frame 31 and the yoke 46 and use the jacks 49, 50 for the clamping only.

A piston 60 is slidable in the cylinder 45. It has an annular piston rod 61 that slides on a piston 62. The piston rod 59 of the piston 62 is fixed to the frame 31. An annular chamber 57 under the piston 60 is washed with water supplied through a supply conduit 58.

A supply passage 63 for hydraulic fluid leads to a cylinder chamber 64 for urging the piston 60 upwardly in a work stroke and a supply passage 65 leads to a cylinder chamber 66 for urging the piston 60 downwardly in a return stroke.

A hydraulic cylinder 69 is coupled between the frame 31 and the shutter 34 and it is arranged to move the shutter 34 between three fixed positions. In the right end position of the shutter 34 illustrated in Fig 4, the cement mixer 35 is coaxial with the cylinder 45. In an intermediate position, the hole 41 is coaxial with the cylinder 45. In the left end position of the shutter, the conical housing 36 of the mixer 35 is open to a hole 67 in the plate 32. A hose 68 leads from the hole 67 to the ground.

A bolt setting operation will now be described.

Before drilling the first hole in a shift or after a break, the cement grout is prepared in the mixer 35. Usually a grout comprising

only a hydraulic cement e.g., portland cement, and water is used, sometimes a cement mortar with fine sand is used. The shutter 34 is first moved to its intermediate position in which the hole 41 is coaxial with the cylinder and the shutter 32 forms a bottom of the cement mixer 35, and the mixer 35 is filled with dry cement or dry cement mortar and a predetermined amount of water is added. The hydraulic motor 38 is started so that the agitator 37 makes a grout out of the cement and water. The shutter 34 is moved to its position in Fig 4 so that the grout fills the cylinder 45 when, from its uppermost position, the piston 60 is moved downwardly by hydraulic oil supplied to the chamber 66 through the passage 65. The length of the downward return stroke can be adjusted by means of an axially adjustable sensor indicated at 70 so that the effective cylinder volume of the positive displacement pump 45, 60 can be pre-determined and a a pre-determined amount of grout be supplied to the cylinder 45. The shutter 34 is again moved to the left in Fig 4 so that it forms a cylinder head provided with an outlet 41. Then, the piston 60 is actuated by hydraulic oil supplied to the chamber 64 through the passage 65 to perform an upward work stroke, that is, to force the grout in the cylinder 45 out into the hose 28. The pressure in the cylinder 45 can for example be 10 Mpa and the pressure in the nozzle 22 may then be 1 Mpa. The jacks 49, 50 are actuated to clamp the cylinder 45 against the shutter 34 at the same time as the cylinder chamber 66 is pressurized so that a good seal is provided between the cylinder 45 and the shutter 34. The operation is repeated until the hose 28 is filled with grout so that grout is ejected from the nozzle when the piston 6 performs a work stroke.

The bolting operation can now start. Thus, the feed beam 14 is positioned and forced against the rock, and the rock drill 17 is actuated to drill a hole in the rock. During the drilling operation, the cylinder 45 is filled with grout and the shutter 34 is moved to its intermediate position in which it forms a head of the cylinder 45 as described above. When the hole has been drilled, the hydraulic cylinder 25 is actuated to position the nozzle 22 in line with the borehole 26. The nozzle 22 is then at the mouth of the borehole. It

is adjacent the mouth but at a distance from the mouth as can be seen in Fig 4. It can for example be a few centimeters from the borehole mouth or a few decimeters from it. Then the piston 60 is actuated to force its predetermined volume of grout out into the hose 28 so that a corresponding amount of grout is ejected out of the nozzle 22 as a jet that reaches the bottom of the hole. The diameter of the nozzle should be smoothly reduced as shown in Fig 4 in order to provide for a jet and not a spray. The outlet diameter of the nozzle should be less than half the diameter of the borehole or less than one third thereof. As an example, the borehole can have a diameter of 40 mm, the anchor rod a diameter of 30 mm and the nozzle an outlet diameter of 8 mm.The amount of grout ejected should not completely fill the hole. It should be calculated to fill the space between the bolt and the borehole when the bolt has been inserted. Thus, the volume of the batch of grout ejected will usually be about half the volume of the borehole. Preferably, the cylinder 45 and the piston 60 are so designed as to provide a sufficient volume of grout in a borehole in one shot. It is, however, also possible to make them smaller and to shoot more than once. Usually, the operator adds dry cement and water to the housing 36 when the magazine 43 for bolts is empty. Then, the grout will be ready to use when he has refilled the magazine 43.

Instead of having the nozzle outside the borehole as described, one can have the nozzle inside the hole. It should then not be inserted too far since it must be outside the portion of the hole which is to be filled with grout. Thus, it should be outside the axial midpoint of the borehole. One advantage of having the nozzle inside the borehole is that it can be designed to be guided by the borehole and thereby aligned with the borehole. However, having the nozzle in the borehole would complicate the operation. It is easier to move the nozzle laterally only, as illustrated.

It is usually unavoidable that the jet touch the borehole wall before reaching the bottom of the hole. However, it has been found that the jet fills the borehole from the bottom if its velocity when

ejected is higher than about 4 m/s. Thus, its velocity should be at least 6 m/s and preferably it should be between 8 and 15 m/s.

When the batch of grout has thus been delivered to the borehole, the bolt setting machine is actuated to force a bolt into the borehole until the plate of the bolt contacts the rock. When the grout has set, the nut 55 can be tightened.

It is a risk that leaking cement will harden on the equipment and make the equipment inoperable. Since a hydraulic cement is used, this problem can be overcome simply by spraying water on vital parts continuously or at short intervals during operation. To this end there are several spray nozzles mounted on the rig. Some vital nozzles are marked out on the drawings. There is a nozzle 72 for sprying on the support 19 and its guides 20, 23 and injection nozzle 22. This spray will also wet the bolts when the bolts are being inserted. Of course, when shooting a jet of grout through the nozzle 22, the spray should be off. Two spray nozzles 73, 74 are mounted to spray on the shutter 34 and a spray nozzle 75 is arranged to spray into the housing 36 when the cover 42 thereof is opened. When the operation is interrupted for a longer period, the housing 36 can be cleaned when the shutter 34 is in its left end position in which the housing 36 is open to the drain off hose 68. Then, when the cleaned housing is moved back into its position of Fig 4, water can be furnished to the housing 36 and the piston 60 can be reciprocated to clean the cylinder 45.

In the above description of the preferred embodiment of the invention, elements that are not vital for the understanding of the invention has not been described in detail. The magazine 42 and its operation for example has not been described in detail. The operation of the shutter 34, the piston 60, and the jacks 49, 50 is preferably carried out automatically as well as the indexing of the support 19 and the exchange of machines on the slide 15.

Claims:

1. A method of roof bolting in which a hole is drilled in the rock, a batch of bulk grout is introduced into the borehole (26), and an anchor rod (24) is forced into the borehole (26), characterized in that the batch of grout is ejected from a nozzle (22) at the mouth of the borehole (26) at such a speed that it forms a jet that reaches the bottom of the borehole.

2. A method according to claim 1, characterized in that a predetermined amount of grout is forced into a grout filled conduit (28) coupled to said nozzle (22) so that a corresponding amount is ejected out of said nozzle as said batch of grout.

3. A method according to claim 2, characterized in that the grout is both metered and forced into the conduit by means of apositive displacement pump (45, 60).

4. A method according to claim 3, characterized in that a pump (45, 60) with a reciprocable piston (60) is used, and the effective cylinder volume of the pump is used to meter the grout.

5. A method according to any one of the preceding claims, characterized in that the jet is ejected out of the nozzle (22) at a velocity of minimum 4 m/s and preferably minimum 6 m/s.

6. A method according to any one of the preceding claims, characterized in that water is flushed on the anchor rod (24) while the anchor rod is being forced into the borehole.

7. A method f roof bolting in which a hole is drilled in the rock, a batch of bulk grout is introduced into the borehole (26), and an anchor rod (24) is forced into the borehole (26), characterized in that the batch of grout is ejected from a nozzle (22) that is positioned in the borehole (26) outside the axial midpoint of the borehole or positioned outside the borehole.

8. A device for introducing a cement grout in a borehole in accordance with the method of any one of the claims 1-7 comprising a storage means (35) for bulk grout, a conduit (28) for conveying the grout from the storage means (35) to the borehole (26), and means (45, 60) for forcing the grout through said conduit (28), characterized in that a nozzle (22) is arranged at the end of said conduit (28) and said means for forcing the grout through the conduit comprises a positive displacement pump (45, 60) arranged to exert such a high pressure on the grout that the grout is ejected as a jet from the nozzle (22).

9. A device according to claim 8, characterized in that said pump (45, 60) comprises a substantially vertical cylinder (45) with a reciprocable piston (60) and means are arranged to alternatively position a first cylinder head (34) provided with an outlet (41) to said conduit (28) and a second cylinder head (34) provided with a grout supply passage (39) into operative positions on the cylinder.

10. A device according to claim 9, characterized in that said first and second cylinder heads (34) are laterally slidable conjointly and said storage means (35) is mounted on said second cylinder head (34).

11. A roof bolting apparatus for carrying out the method of any one of the claims 1-7 comprising a chassis (12), a boom (13)

swingably mounted on the chassis, an assembly (14) pivotably mounted on the distal end of the boom and comprising a rock drill (17), means (22) for introducing a cement grout in the borehole and a bolt setter (29), said rock drill (17), said means (22), and said bolt setter (29) being sequentially movable into their operating position on the assembly (14),

c h a r a c t e r i z e d i n

that said means for introducing the hardenable medium in the borehole comprises a nozzle (22) which has its operational position at the mouth of a borehole (26) drilled by the rock drill and is coupled to a positive displacement pump (45, 60) mounted on the chassis (12), and in that a cement grout storage means (35) is mounted on the chassis (12) and arranged to feed the pump (45, 60) said pump (45, 60) being arranged to exert such a high pressure on the grout that the grout is ejected as a jet from the nozzle (22).

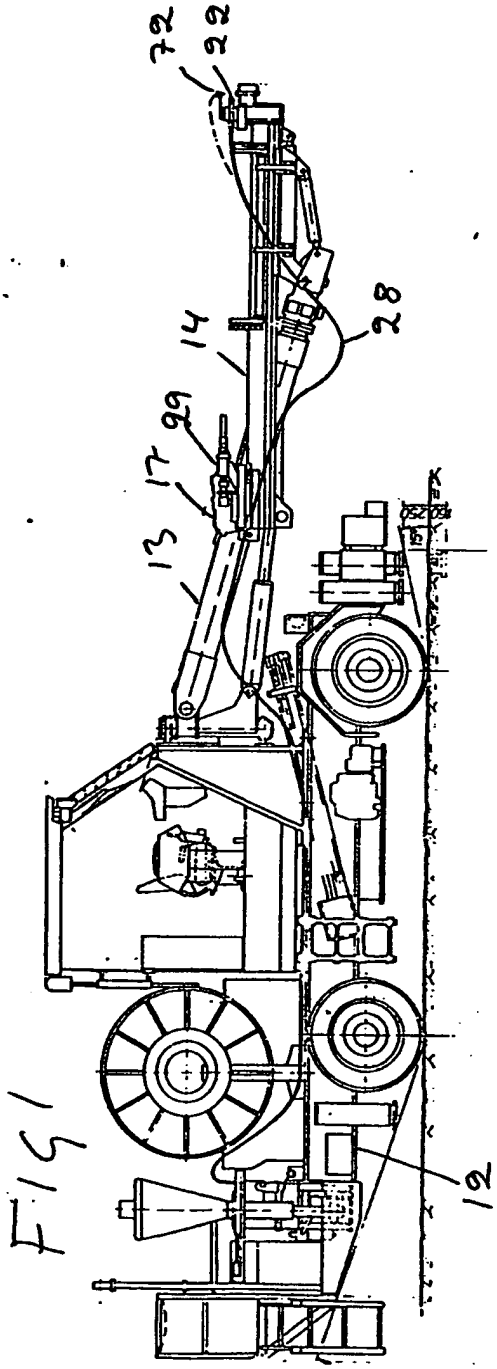

FIG 1

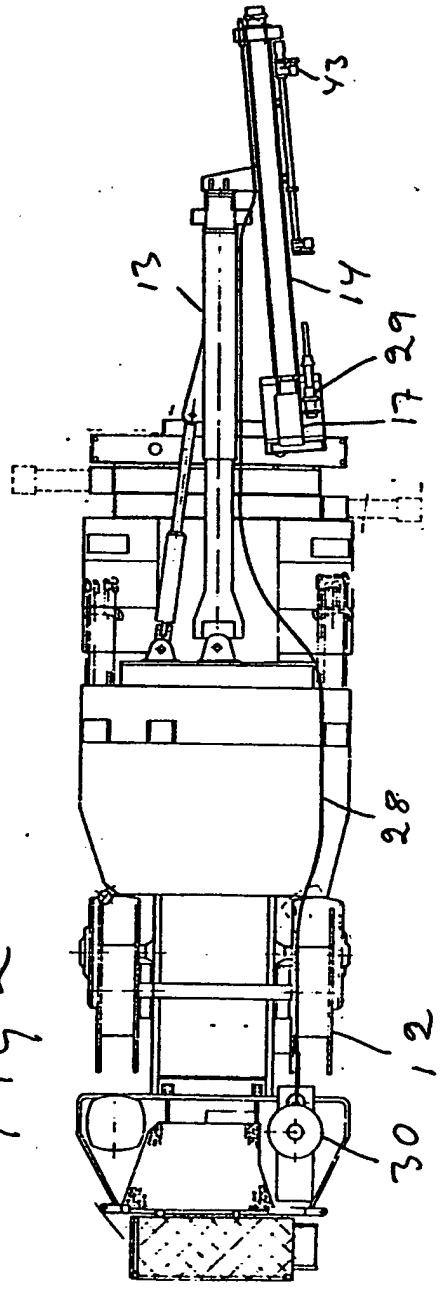

FIG 2

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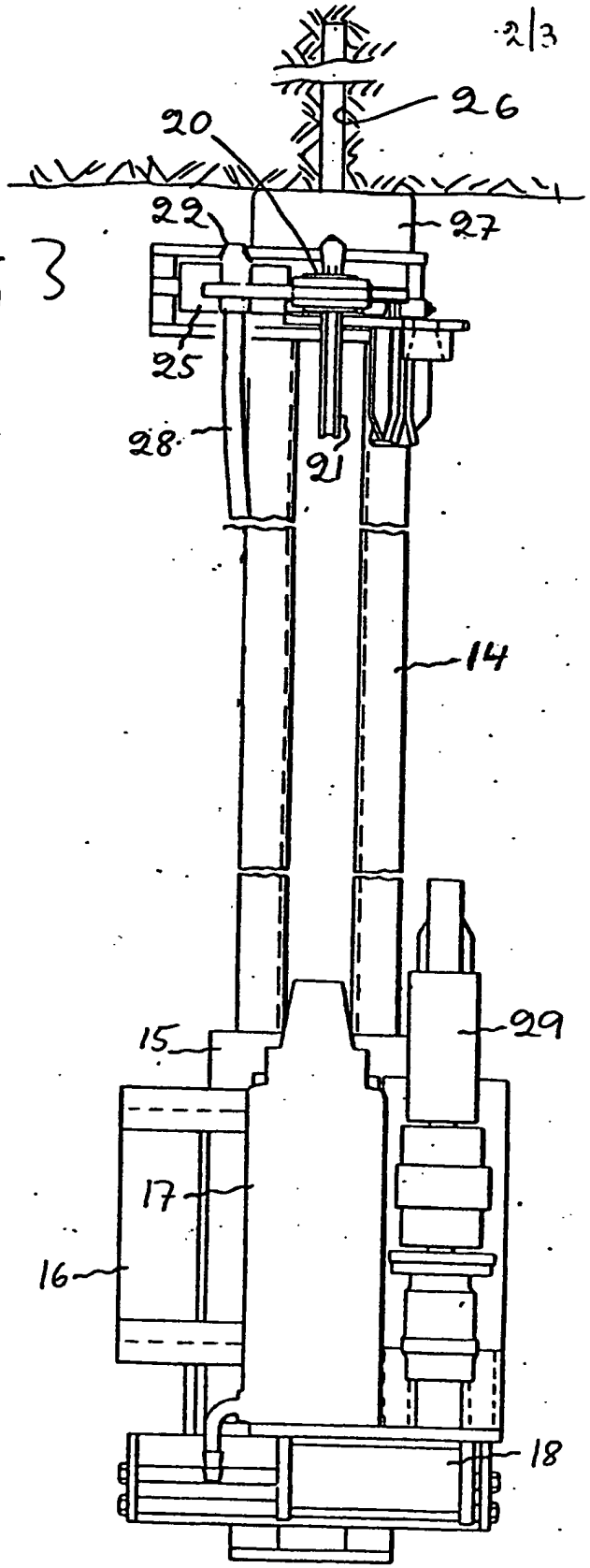
FIG 3



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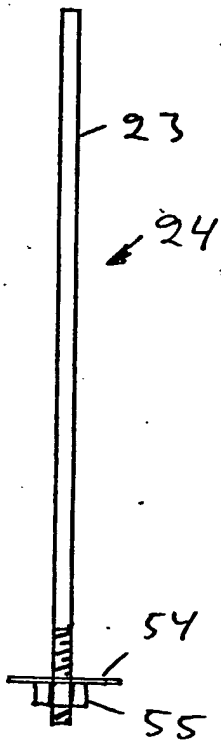

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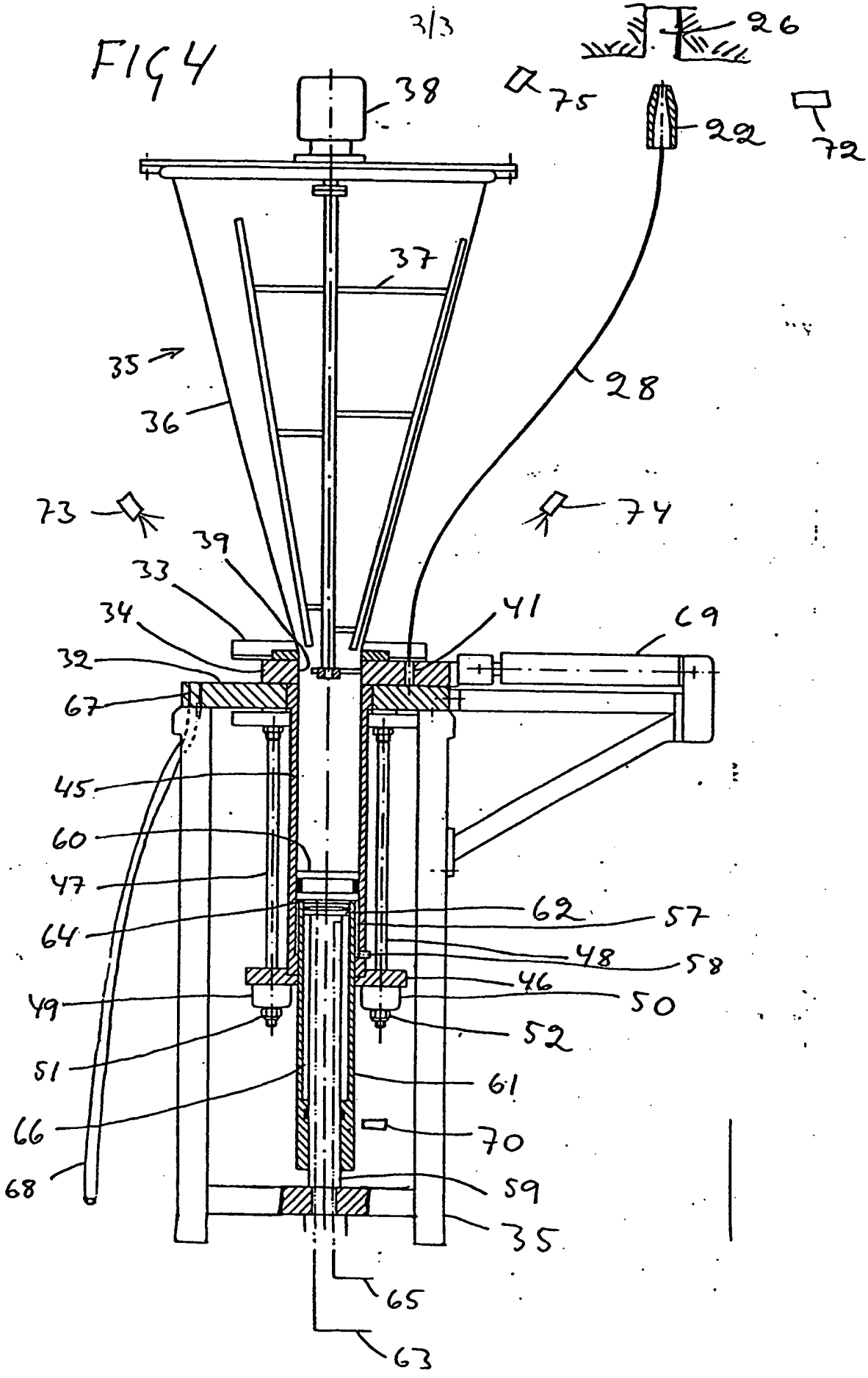
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0126046
Application number

EP 84 85 0123

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
X,A	DE-A-2 750 532 (FISCHER) * Claim 1 *	1,3,4	E 21 D 20/02
X,A	DE-A-2 838 466 (BERNACK) * Claim 1 *	1,3,4	
X,A	DE-A-2 925 197 (DELECKER) * Claim 1 *	1,3,4	
X	DE-A-3 005 484 (LINDEN-ALIMAK) * Claim 1 *	1-4	
X	CH-A- 455 405 (TOX-DÜBEL-WERK R. HECKHAUSEN) * Claim 1 *	1	
X,A	FR-A- 714 997 (RAWLINGS et al.) * Claim *	1,3,4	TECHNICAL FIELDS SEARCHED (Int. Cl. ³) E 21 D 20/00 E 21 D 21/00 E 21 F 17/00 F 16 B 13/14
X	FR-A-2 402 059 (ATLAS COPCO) * Figures 2, 3 *	1,2	
X	GB-A-1 503 904 (FOSROC INTERNATIONAL) * Figure 2 *	1-4	
X	GB-A-2 095 308 (WILLICH) * Figure 1 *	1	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	05-07-1984	ZAPP E

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EUROPEAN SEARCH REPORT

Application number

EP 84 85 0123

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
X,A	US-A-4 215 953 (PERRAUD) * Figure 1 * -----	1,3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.³)

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BERLIN	05-07-1984	ZAPP E

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